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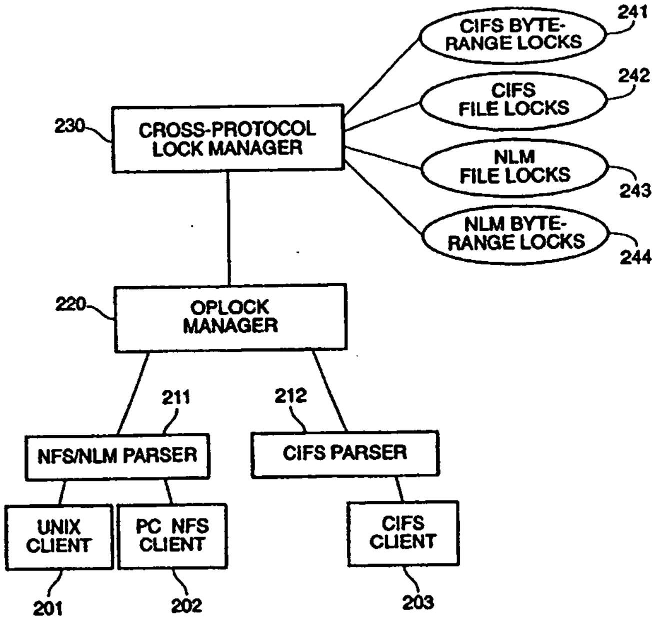
(57) Abstract

The invention provides a method and system for correct interoperation of multiple diverse file server or file locking protocols, using a uniform multi-protocol lock management system. A file server determines, before allowing any client device to access data or to obtain a lock, whether that would be inconsistent with existing locks, regardless of originating client device or originating protocol for those existing locks. A first protocol enforces mandatory file-open and file-locking together with an opportunistic file-locking technique, while a second protocol lacks file-open semantics and provides only for advisory byte-range and file locking. Enforcing file-locking protects file data against corruption by NFS client devices. A CIFS client device, upon opening a file, can obtain an "oplock" (an opportunistic lock). When a client device issues a non-CIFS protocol request for the oplocked file, the file server sends an oplock-break message to the CIFS client device, giving the CIFS client device the opportunity to flush any cached write operations and possibly close the file. Allowing NFS and NLM requests to break oplocks ensures that file data remains available to NFS client devices simultaneously with protecting integrity of that file data. A CIFS client device can obtain a "change-monitoring" lock for a directory in the file system, so as to be notified by the file server whenever there is a change to that directory. The file server notes changes to the directory by both CIFS and non-CIFS client devices, and notifies those CIFS client devices with "change-monitoring" locks of those changes.



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Title of the Invention

Multi-Protocol Unified File-locking

Backgrounc of the Invention

1. *Field of the Invention*

The invention relates to locking in a multi-protocol file server.

2. *Related Art*

In an integrated computer network, it is desirable for multiple client devices to share files. One known method is to provide a network file server for storing files, capable of receiving and responding to file server requests from those client devices. These file server requests are made using a file server protocol, which is recognized and adhered to by both the file server and the client device. Because the files are stored at the file server, multiple client devices have the opportunity to share simultaneous access to files.

One problem in the art is that there are multiple diverse file server protocols, each with differing semantics for file operations. It is known to provide a single file server that recognizes multiple file server protocols, but there is a particular difficulty in that many file server protocols have differing and incompatible semantics for file locking and file sharing. Incompatible locking semantics presents a hurdle in providing a single file system to multiple diverse client devices. If a first client device relies on a first file server protocol (having first file-locking semantics), a second client device using a second file server protocol (having different file-locking semantics) can cause applications at that first client device to fail catastrophically. Thus, correct operation of each file server protocol relies on conformity with its file-locking semantics by all other file server protocols.

For example, one protocol commonly used for devices using the Unix operating system (or a variant thereof) is the NFS ("Network File System") protocol. Devices using the Windows operating system (or a variant thereof) can also use the NFS protocol by means of the "PC NFS" implementation. The NFS protocol is designed to be stateless, and so does not provide any semantics for files to be locked against sharing or otherwise restricted to a single client device. In contrast, one protocol commonly used for devices using the Windows operating system is the CIFS ("Common Internet File System") protocol. The CIFS protocol has an extensive mandatory file-locking semantics, which CIFS client devices rely on and expect to be adhered to.

In known systems, the NFS protocol has been augmented with an adjunct file-locking protocol, NLM ("Network Lock Manager"), but the NFS protocol treats NLM locks as merely advisory. While this method achieves the purpose of providing file-locking semantics to those NFS applications that use it, it does not prevent NFS applications from ignoring those file-locking semantics, nor does it allow client devices to rely on the file-locking semantics of multiple diverse file server protocols.

Accordingly, it would be desirable to provide a method and system for enforcing file-locking semantics among client devices using multiple diverse file server protocols. This advantage is achieved in an embodiment of the invention in which a uniform set of file-locking semantics is integrated into the kernel of a multi-protocol file server and enforced for client devices using any of the diverse file server protocols recognized by the server. In a preferred embodiment, specific file-locking semantics of the CIFS protocol are implemented so as to allow NFS client devices to inter-operate with CIFS client devices so as to protect data integrity during client access to a shared file system resident on a network file server.

Summary of Invention

The invention provides a method and system for correct interoperation of multiple diverse file server protocols. A file server recognizing multiple diverse file server protocols provides a uniform multi-protocol lock management system (including a uniform file-locking semantics), which it enforces for all client devices and all recognized file server protocols. In a preferred embodiment, a first file server protocol (such as CIFS) enforces mandatory file-open and file-locking semantics together with an opportunistic file-locking technique, while a second file server protocol (such as NFS, together with an adjunct protocol NLM) lacks file-open semantics and provides only for advisory byte-range and file locking semantics.

The uniform file-locking semantics provides that the file server determines, before allowing any client device to read or write data, or to obtain a new file lock or byte-range lock, whether that would be inconsistent with existing locks, regardless of originating client device and regardless of originating file server protocol or file-locking protocol for those existing locks. In the case of CIFS client devices attempting to read or write data, the file server performs this check when the client device opens the file. In the case of CIFS client devices requesting a byte-range lock, the file server performs this check when the client device requests the byte-range lock. In the case of NFS client devices, the file server performs this check when the client device actually issues the read or write request, or when the NFS client device requests an NLM byte-range lock indicating intent to read or write that byte range. Enforcing file-locking semantics protects file data against corruption by NFS client devices.

In a second aspect of the invention, a CIFS client device, upon opening a file, can obtain an "oplock" (opportunistic lock), an exclusive file lock that permits only that one client to read or write the file. When a client device issues a non-CIFS (that is, NFS or NLM) protocol request for the oplocked file, the file server sends an oplock-break message to the CIFS client device, giving the CIFS client device the opportunity to flush any cached write operations and possibly close the file. Allowing NFS and NLM requests to break oplocks ensures that file data remains available to NFS client devices simultaneously with protecting integrity of that file data.

In a third aspect of the invention, a CIFS client device can obtain a "change-monitoring" lock for a directory in the file system, so as to be notified by the file server whenever there is a change to that directory. (Changes to a directory include creating, deleting or renaming files within that directory, or moving files into or out of that directory.) The file server notes changes to the directory by both CIFS client devices and non-CIFS client devices, and notifies those CIFS client devices with "change-monitoring" locks of those changes.

Brief Description of the Drawings

Figure 1 shows a first block diagram of a system including a multi-protocol file server.

Figure 2 shows a second block diagram of a system including a multi-protocol file server.

Figure 3 shows a process flow diagram of a method of operating a multi-protocol file server.

Figure 4 shows a process flow diagram of a method of operating a cross-protocol lock manager in a multi-protocol file server.

Figure 5 shows a process flow diagram of a method of operating an oplock manager in a multi-protocol file server.

Figure 6 shows a process flow diagram of a method of operating a change-notify manager in a multi-protocol file server.

Detailed Description of the Preferred Embodiment

In the following description, a preferred embodiment of the invention is described with regard to preferred process steps and data structures. Those skilled in the art would recognize after perusal of this application that embodiments of the invention can be implemented using general purpose processors or special purpose processors or other circuits adapted to particular process steps and data structures described herein, and that implementation of the process steps and data structures described herein would not require undue experimentation or further invention.

System Architecture (Client/Server)

Figure 1 shows a first block diagram of a system including a multi-protocol file server.

A system 100 includes a file server 110, a computer network 120, and a plurality of client devices 130.

The file server 110 includes a processor 111 and mass storage 112. The mass storage 112 is capable of storing and retrieving a set of files 113 having data for storage and retrieval. The processor 111 is capable of receiving a sequence of request messages 121 from the network 120, parsing those messages as commands and data, and manipulating the files 113 on the mass storage 112, and sending response messages, in response to those commands and data.

The file server 110 and the client devices 130 are coupled to the network 120 and communicate using messages 121 transmitted on the network 120. The messages 121 include file system requests transmitted by the client devices 130 to the file server 110 and file system responses transmitted by the file server 110 to the client devices 130.

System Architecture (File-Locking Semantics)

Figure 2 shows a second block diagram of a system including a multi-protocol file server..

The system 100 includes the set of client devices 130, including Unix client devices 201, PC NFS Windows client devices 202, and CIFS Windows client devices 203. Unix client devices 201 execute the Unix operating system and use the Unix/NFS file server protocol. PC NFS Windows client devices 202 execute the Windows operating system and use the PC NFS file server protocol. CIFS Windows client devices 203 execute the Windows operating system and use the CIFS file server protocol.

Unix client devices 201 and PC NFS Windows client devices 202 communicate with the file server 110 using the NFS file server protocol, which is recognized at the file server 110 by an NFS file server protocol parser 211. CIFS Windows client devices 203 communicate with the file server 110 using the CIFS file server protocol, which is recognized at the file server 110 by a CIFS file server protocol parser 212. Messages using either the NFS file server protocol or the CIFS file server protocol are parsed by the processor 111 and processed by an oplock manager 220.

The oplock manager 220 manages access to files 113 having CIFS oplocks. Its operation is described in further detail with regard to figure 3 and figure 5. The oplock manager element 220 is coupled to a cross-protocol lock manager 230.

The cross-protocol lock manager 230 manages the file-locking semantics of the file server 110. It processes and records information regarding four types of locks—CIFS byte-range locks 241, CIFS file locks 242, PC NFS (NLM) file locks 243, and NLM byte-range locks 244. Its operation is described in further detail with regard to figure 3 and figure 4.

Differing File-Locking Semantics

As noted with regard to figure 2, file server request messages 140 can be received from Unix client devices 201, PC NFS Windows client devices 202, or CIFS Windows client devices 203, and can use the NFS file server protocol or the CIFS file server protocol. In addition to each using differing file server protocols, each of these types of client device 130 has a different model of file locking provided by the file server 110.

In particular, the NFS file server protocol provides for performing file system operations without any form of file-open or file-close semantics. These NFS file system operations can include read or write operations to file data, or file system manipulation (that is, read and write operations to directories). File system manipulation can include creating files or directories, renaming files or directories, moving files from one directory to another, or removing (deleting) files or directories from the file system.

The NLM adjunct protocol provides for obtaining and releasing byte-range locks for files. These byte-range locks can be "read locks," which induce other compliant applications (such as at other client devices 130) to refrain from writing to the specified byte-range. These byte-range locks can alternatively be "write locks," which induce other compliant applications to refrain from either reading from or writing to the specified byte-range.

The CIFS file server protocol provides for performing file-open operations, and obtaining file locks on the files 113 to be opened, before attempting any read or write operations to data in those files 113. At file-open time, a CIFS client device 130 can specify the access-mode it desires (read-only, write-only, or read-write), and the deny-mode it desires to impose on other client devices 130 attempting to open the same file 113 (deny-none, deny-read, deny-write, or deny-all). Thereafter, CIFS file system operations need only be checked against the access-mode that the file-open obtained. A CIFS client device 130 can also specify a byte-range lock for a byte-range in a file the client device 130 holds open. The byte-range lock is either an exclusive lock, also called a "write lock" (having access-mode read-write and deny-mode deny-all), or a nonexclusive lock, also called a "read lock" (having access-mode read-only and deny-mode deny-write).

The file server 110 determines a lock mode that combines the access-mode and the deny-mode. As used herein, the phrase "lock mode" refers to a uniform lock mode imposed by the file server 110 which combines an access-mode and a deny-mode.

At file-open time, CIFS client devices 130 can also obtain an oplock (opportunistic lock), which provides that the CIFS client device 130 opening the file has exclusive access to the file so long as another client device 130 does not attempt to use the file. The oplock provides a higher degree of exclusivity to the file than strictly necessary for the client device 130, with the caveat that the exclusivity of the oplock can be broken by attempted access by another client device 130.

The file server 110 provides for correct interoperation among client devices 130 using NFS (with or without the adjunct protocol NLM) or CIFS. To provide for correct interoperation, the file server 110 provides a uniform file-locking semantics. In a preferred embodiment, the uniform file-locking semantics has the following effects:

The file server 110 prevents Unix client devices 201 from performing NFS write operations that would overwrite data in a file 113 that is already opened and in use by a CIFS client with deny-modes deny-write or deny-all.

The file server 110 prevents Unix client devices 201 and PC NFS Windows client devices 202 from performing NFS file system operations that would remove or rename a file 113 that is already opened and in use by a CIFS client.

When a Unix client device 201 or a PC NFS Windows client device 202 makes an NFS request to remove, rename, or write data to a file 113 that is oplocked by a CIFS client, the file server 110 will enforce CIFS oplock semantics for the file 113. The file server 110 sends an oplock-break message 140 to the client device 130 holding the oplock, and receives a response from the client device 130. If the client device 130 closes the file 113, the NFS request can proceed and the file server 110 allows it to.

When a Unix client device 201 or a PC NFS Windows client device 202 makes an NFS request to read data from a file 113 that is oplocked by a CIFS client, the file server 110 will enforce CIFS oplock semantics for the file 113. The file server 110 sends an oplock-break message 140 to the client device 130 holding the oplock, and receives a response from the client device 130. When the client device 130 either closes the file 113 or flushes its write cache to the file server 110, the NFS request can proceed and the file server 110 allows it to.

The file server 110 tests for mutual compatibility for file-open requests from CIFS Windows client devices 203, and NLM file lock requests from PC NFS Windows client devices 202, with regard to their specified lock modes. The phrase NLM "file lock" is used herein in place of the known phrase NLM "share lock," further described in the following document: "X/Open CAE Specification: Protocols for X/Open Interworking: XNFS, Issue 4 (X/Open Document Number C218), hereby incorporated by reference as if fully set forth herein. The specified lock mode is determined by the file server 110 by combining the requested access-mode and deny-mode.

To provide these effects, the file server 110 performs the following lock management operations:

Upon receiving a CIFS file-open request message 140, the file server 110 tests the file-open request for conflict with existing CIFS and NLM file locks, and for conflict with existing NLM byte-range locks. For the purpose of comparison with newly requested file locks, the file server 110 treats existing NLM byte-range locks as having deny-mode deny-none, and as having access-mode read-only for nonexclusive locks and access-mode read-write for exclusive locks.

Upon receiving a CIFS byte-range lock request message 140, the file server 110 tests the byte-range lock request for conflict with existing CIFS and NLM byte-range locks.

Upon receiving an NLM byte-range lock request message 140, the file server 110 tests the byte-range lock request for conflict with existing CIFS and NLM byte-range locks, and for conflict with existing CIFS file locks.

Upon receiving an NLM file lock request message 140 from a PC NFS client device 130 (used to simulate a file-open request message 140), the file server 110 tests the NLM file lock request for conflict with existing CIFS and NLM file locks, and for conflict with existing NLM byte-range locks. For the purpose of comparison with newly requested NLM file locks, the file server 110 treats existing NLM byte-range locks as having deny-mode deny-none, and as having access-mode read-only for nonexclusive locks and access-mode read-write for exclusive locks.

Method of Operation (Multi-Protocol File Server)

Figure 3 shows a process flow diagram of a method of operating a multi-protocol file server.

A method 300 of operating a multi-protocol file server includes a set of process steps and flow points as described herein, to be performed by the file server 110 in cooperation with at least one client device 130.

At a flow point 310, the file server 110 is ready to receive the file server request message 140.

At a step 311, the file server 110 receives and parses the file server request message 140. The file server 110 determines if the file server request message 140 uses the NFS file server protocol, the NLM file locking protocol. or the CIFS file server protocol. If the file server request message 140 uses the NFS file server protocol or the NLM file locking protocol, the method 300 continues with the step 312. If the file server request message 140 uses the CIFS file server protocol, the method 300 continues with the step 313.

At a step 312, the file server 110 determines if the request message 140 includes an NFS file server request to perform a file system operation (such as to read or write data, or to modify a directory). Alternatively, the file server 110 determines if the request message 140 includes an NLM file-locking request to obtain an NLM byte-range lock. In either case, the method 300 continues at the flow point 320.

At a step 313, the file server 110 determines if the file server request message 140 is to perform a CIFS read or write operation, to obtain a CIFS byte-range lock, or to perform a CIFS file-open operation. In the file server request message 140 is to obtain a CIFS byte-range lock or to perform a CIFS file-open operation, the method 300 continues at the flow-point 320. If the file server request message 140 is to perform a CIFS read or write operation, the method continues at the flow-point 330. If the file server request message 140 is a CIFS "change-notify" request, the method continues at the flow point 350 (the change-notify request is further described with regard to figure 6).

At a flow point 320. the file server 110 is ready to compare the operation requested by the file server request message 140 with the file-locking status of the file 113. The file-locking status of the file 113 includes existing file locks and byte-range locks for the file 113.

At a step 321, the file server 110 determines the file 113 that is the subject of the file server request message 140, and determines if the file 113 is oplocked. If the file 113 is oplocked, the method 300 continues with the step 322. If the file 113 is not oplocked, the method 300 continues with the step 323.

At a step 322, the file server 110 breaks the oplock, as described herein. Performance of the step 322 is further described with regard to figure 5. Breaking the oplock can cause the file-locking status of the file 113 to change.

At a step 323, the file server 110 compares the requested operation with the file-locking status of the file 113, using a uniform file-locking semantics. In this step, the requested operation can be an NFS read or write operation, an NFS or CIFS directory modification operation, an attempt to obtain an NLM file lock or byte-range lock, or a CIFS file-open operation. Performance of the step 323 and the uniform file-locking semantics are further described with regard to figure 4. If the comparison shows that the requested operation is allowable, the method 300 continues with the step 324. If the requested operation is not allowable, the method 300 continues with the step 325.

At a step 324, the file server 110 performs the requested operation. The method 300 continues at the flow point 340.

At a step 325, the file server 110 refuses to perform the requested operation and responds to the client device 130 with an error message. The method 300 continues at the flow point 340.

At a flow point 330, the file server 110 is ready to compare the operation requested by the file server request message 140 with the file-locking status of the file 113.

At a flow point 350, the file server 110 is ready to perform the change-notify operation, as described herein.

At a step 351, a first CIFS client device 130 requests a file lock for a directory (using a file system request message 140 to open the directory), and converts the file lock for the directory to a change-monitoring lock on the directory. Performance of this step 351 is further described with regard to figure 6.

At a flow point 340, the file server 110 has responded to the file server request message 140, and the method 300 is complete with regard to that file server request message 140.

Method of Operation (Cross-Protocol Lock Manager)

Figure 4 shows a process flow diagram of a method of operating a cross-protocol lock manager in a multi-protocol file server.

A method 400 of operating a cross-protocol lock manager in a multi-protocol file server includes a set of process steps and flow points as described herein, to be performed by the file server 110 in cooperation with at least one client device 130.

At a flow point 410, the file server 110 is ready to compare the requested operation in the file server request message 140, with the file-locking status of the file 113.

The file server 110 uses a uniform file-locking semantics, so as to model file-locking aspects of any requested operation from any file server protocol in the same way. The uniform file-locking semantics identifies a uniform set of file locks, each including an access-mode for the requesting client device 130 and a deny-mode for all other client devices 130.

In a preferred embodiment, the access-mode can be one of three possibilities—read-only, write-only, or read-write. Similarly, in a preferred embodiment, the deny-mode can be one of four possibilities—deny-none, deny-read, deny-write, or deny-all.

After a first client device 130 obtains a file lock for a file 113, a second client device 130 can only access that file 113 if the lock mode determined by the file server 110 to be requested by the second client device 130 is compatible with the file-locking status of the file 113. For example, a first client device 130 can obtain a file lock for a file 113 with a deny-mode deny-write. A second NFS client device 130 could attempt to write to the file 113, or a second

CIFS client device 130 could attempt to open the file 113 with an access-mode including write access. In either such case (if the file lock for the file 113 is not an opportunistic lock, as further described herein), the file server 110 will deny the request by the second client device 130.

As noted herein, the file server 110 performs the comparison of the file lock with the access requested by the second client device 130 at differing times, in response to the file server protocol used by the second client device 130:

If the second client device 130 uses the CIFS file server protocol to open the file 113, the file server 110 checks the file-locking status of the file 113 at file-open time.

If the second client device 130 uses the NFS file server protocol to read or write to the file 113, the file server 110 checks the file-locking status of the file 113 at the time of the actual file system operation. This also applies to file system operations that have the effect of removing the file from view of the first client device 130, such as operations to move, remove, or rename the file 113.

If the second client device 130 uses the CIFS file server protocol to request a byte-range lock, the file server 110 checks the file-locking status of the file 113 for conflict with other CIFS or NLM byte-range locks, at the time the byte-range lock is requested. The file server 110 does not check for conflict with other CIFS file locks at the time the byte-range lock is requested, because those were checked at file-open time.

If the second client device 130 uses the NLM protocol to request a byte-range lock, the file server 110 checks the file-locking status of the file 113 for conflict with existing CIFS or NLM byte-range locks, and for conflict with existing CIFS file locks, at the time the byte-range lock is requested.

At a step 421, the file server 110 determines if there is already more than one file lock associated with the file 113. If so, the method 400 continues with the step 422. If not, the method continues with the step 411.

At a step 422, the file server 110 combines file locks already associated with the file 113 into a single equivalent file lock associated with the file 113. To perform this step 422, the file server 110 cross-indexes in table 1 a cumulative file lock with each pre-existing file lock, until all pre-existing file locks have been cumulated together.

Table 1 shows a lock conversion table in a multi-protocol file server with unified file-locking semantics.

		Existing file lock mode										
		NULL	A: R D: DN	A: W D: DN	A: RW D: DN	A: R D: DR	A: W D: DR	A: RW D: DR	A: R D: DW	A: W D: DW	A: RW D: DW	A: Any D: DA
New lock mode	NULL	NULL	A: R D: DN	A: W D: DN	A: RW D: DN	A: R D: DR	A: W D: DR	A: RW D: DR	A: R D: DW	A: W D: DW	A: RW D: DW	A: Any D: DA
	A: R D: DN	A: R D: DN	A: R D: DN	A: RW D: DN	A: RW D: DN	A: R D: DR	A: RW D: DR	A: RW D: DR	A: R D: DW	A: RW D: DW	A: RW D: DW	A: Any D: DA
	A: W D: DN	A: W D: DN	A: RW D: DN	A: W D: DN	A: RW D: DN	A: RW D: DR	A: W D: DR	A: RW D: DR	A: RW D: DW	A: W D: DW	A: RW D: DW	A: Any D: DA
	A: RW D: DN	A: RW D: DN	A: RW D: DN	A: RW D: DN	A: RW D: DN	A: RW D: DR	A: RW D: DR	A: RW D: DR	A: RW D: DW	A: RW D: DW	A: RW D: DW	A: Any D: DA
	A: R D: DR	A: R D: DR	A: R D: DR	A: RW D: DR	A: RW D: DR	A: R D: DR	A: RW D: DR	A: RW D: DR	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA
	A: W D: DR	A: W D: DR	A: RW D: DR	A: W D: DR	A: RW D: DR	A: RW D: DR	A: W D: DR	A: RW D: DR	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA
	A: RW D: DR	A: RW D: DR	A: RW D: DR	A: RW D: DR	A: RW D: DR	A: RW D: DR	A: RW D: DR	A: RW D: DR	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA
	A: R D: DW	A: R D: DW	A: R D: DW	A: RW D: DW	A: RW D: DW	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: R D: DW	A: RW D: DW	A: RW D: DW	A: Any D: DA
	A: W D: DW	A: W D: DW	A: RW D: DW	A: W D: DW	A: RW D: DW	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: RW D: DW	A: W D: DW	A: RW D: DW	A: Any D: DA
	A: RW D: DW	A: RW D: DW	A: RW D: DW	A: RW D: DW	A: RW D: DW	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: RW D: DW	A: RW D: DW	A: RW D: DW	A: Any D: DA
	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA	A: Any D: DA

Table 1

Lock Conversion Matrix

A = Access Mode (R = Read, W = Write, RW = Read-Write, Any = any one of R or W or RW)

D = Deny Mode (DN = Deny None, DR = Deny Read, DW = Deny Write, DA = Deny All)

At a step 411, the file server 110 determines the nature of the requested operation in the file server request message 140. If the requested operation is a CIFS file-open operation, the method 400 continues with the step 423. If the requested operation is an NFS file server operation, the method 400 continues with the step 431. If the requested operation is either a

CIFS request an NLM request for a byte-range lock. the file system 110 continues with the step 441.

At a step 423, the file server 110 compares the file lock already associated with the file 113 with the file open requested by the second client device 130. To perform this step 423, the file server 110 cross-indexes in table 2 the pre-existing file lock and the requested new access-mode and deny-mode, and allows or denies the requested new access-mode and deny-mode in response to the associated table entry.

If the file server 110 allows the requested new access-mode and deny-mode, the method 400 performs the step 424. If the file server 110 denies the requested new access-mode and deny-mode, the method 400 does not perform the step 424.

Table 2 shows a cross-index of attempted file locks in a multi-protocol file server with unified file-locking semantics.

		Pre-existing file lock										
		NULL	A: R D: DN	A: R D: DR	A: R D: DW	A: W' D: DN	A: W D: DR	A: W D: DW	A: RW D: DN	A: RW D: DR	A: RW D: DW	A: Any D: DA
New mode being requested	NULL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	A: R D: DN	✓	✓	X	✓	✓	X	✓	✓	X	✓	X
	A: R D: DR	✓	X	X	X	✓	X	✓	✓	X	✓	X
	A: R D: DW	✓	✓	X	✓	X	X	X	X	X	X	X
	A: W D: DN	✓	✓	✓	X	✓	✓	X	✓	✓	X	X
	A: W D: DR	✓	X	X	X	✓	✓	X	X	X	X	X
	A: W D: DW	✓	✓	✓	X	X	X	X	X	X	X	X
	A: RW D: DN	✓	✓	X	X	✓	X	X	✓	X	X	X
	A: RW D: DR	✓	X	X	X	✓	X	X	X	X	X	X
	A: RW D: DW	✓	✓	X	X	X	X	X	X	X	X	X
	A: Any D: DA	✓	X	X	X	X	X	X	X	X	X	X

Table 2

Multi-Protocol Lock Compatibility Matrix

A = Access Mode. D = Deny Mode

✓ = New request will be granted. X = New request will be denied.

As shown in table 2, each pair of pre-existing file lock and requested new access-mode and deny-mode has an associated decision to allow or to deny the requested new access-mode and deny-mode.

If the file server 110 is checking for conflicts between an existing CIFS file lock and a new request to perform a file-open operation, the existing CIFS file lock is cross-indexed against the access-mode and deny-mode requested in the new file-open request.

If the file server 110 is checking for conflicts between existing file locks and a new NFS request to perform a file read or write operation, the aggregate lock mode (the combination of existing file locks) is cross-indexed against the access-mode required to perform the new request.

If the file server 110 is checking for conflicts between existing file locks or byte-range locks, and a new request for a NLM byte-range lock, the existing file locks and byte-range locks are cross-indexed against a lock mode equivalent to the new NLM byte-range lock request. For the purpose of comparing with existing file locks, the file server 110 treats newly requested NLM byte-range locks as having deny-mode deny-none, and as having access-mode read-only for nonexclusive locks (also called "read locks") and access-mode read-write for exclusive locks (also called "write locks"). For the purpose of comparing with existing byte-range locks, the file server 110 treats newly requested NLM byte-range locks as having access-mode read-only and deny-mode deny-write for read locks, and as having access-mode read-write and deny-mode deny-all for write locks.

The method 400 then continues at the flow point 450.

At a step 431, the file server 110 compares the file-locking status of the file 113 with the operation requested by the second client device 130. To perform this step 431, the file server 110 compares the deny-mode for the file lock with the requested operation, and allows or denies the requested operation in response thereto.

The method 400 then continues at the flow point 450.

At a step 441, the file server 110 compares the file-locking status of the file 113 with the NLM byte-range lock requested by the second client device 130. In a preferred embodiment, CIFS byte-range lock requests are only checked against byte-range locks because they require a prior CIFS file open operation at which existing file locks were already checked. To perform this step 441, the file server 110 cross-indexes in table 3 the pre-existing file-locking status and the requested byte-range lock, and allows or denies the requested byte-range lock in response to the associated table entry.

If the file server 110 allows the requested new NLM byte-range lock, the method 400 performs the step 442. If the file server 110 denies the requested new byte-range lock, the method 400 does not perform the step 442.

Table 3 shows a cross-index of existing file locks and newly requested NLM byte-range locks in a multi-protocol file server with unified file-locking semantics.

	Existing lock mode										
	None	A: R D: DN	A: R D: DR	A: R D: DW	A: W D: DN	A: W D: DR	A: W D: DW	A: RW D: DN	A: RW D: DR	A: RW D: DW	A: Any D: DA
Write Lock	✓	✓	✓	X	✓	✓	X	✓	✓	X	X
Read Lock	✓	✓	X	✓	✓	X	✓	✓	X	✓	X

Table 3

Compatibility of new NLM byte-range locks with existing file locks

A = Access Mode, D = Deny mode

✓ = New NLM byte-range lock request will be granted.

X = New NLM byte-range lock request will be denied.

As shown in table 3, each pair of existing file lock and newly requested NLM byte-range lock has an associated decision to allow or to deny the requested new byte-range lock.

At a step 442, the file server 110 associates the requested new byte-range lock with the file 113 as a new additional byte-range lock.

The method 400 then continues at the flow point 450.

At a flow point 450, the file server 110 has compared the requested operation in the file server request message 140 with the file-locking status of the file 113, and allowed or denied the requested operation.

Method of Operation (Oplock Manager)

Figure 5 shows a process flow diagram of a method of operating an oplock manager in a multi-protocol file server.

A method 500 of operating a oplock manager in a multi-protocol file server includes a set of process steps and flow points as described herein, to be performed by the file server 110 in cooperation with at least one client device 130.

Oplocks are known in the art of file-locking in Windows operating system environments. They are further described in documentation available for the "Windows NT 4.0" operating system. available from Microsoft Corporation of Redmond, Washington, including for example the CIFS IETF specification. available via the FTP protocol at host ftp.microsoft.com, directory /developr/drg/CIFS, files cifs6.doc or cifs6.txt, hereby incorporated by reference as if fully set forth herein.

At a flow point 510, the file server 110 is ready to receive a request from a CIFS first client device 130 to open a file 113.

At a step 511, the file server 110 receives a file-open request for a file 113 from a CIFS first client device 130. The file-open request designates an access-mode and a deny-mode.

At a step 512, the file server 110 determines that it should allow the request, and grants the first client device 130 a file lock with the designated access-mode and deny-mode.

At a step 513, if the client device 130 has requested an oplock on the file open request, the file server 110 grants the first client device 130 an oplock at a level of exclusivity possibly greater than the first client device 130 actually requires.

For example, when a CIFS first client device 130 opens a file 113 with the access-mode read-only and deny-mode deny-write, the file server 110 associates a file lock of that type with the file 113. The file server 110 further associates an oplock with the file 113 with the access-mode read-write and deny-mode deny-all.

At a flow point 520, the file server 110 has responded to the request from the CIFS first client device 130 for a file lock for a file 113.

At a flow point 530, a second client device 130 attempts to open the file 113.

At a step 531, the file server 110 receives either a file-open request from a second CIFS client device 130 or a NLM file lock request from a PC NFS client device 130.

As part of performing this step 531, the file server 110 suspends execution of the request by the second client device 130 while it breaks the oplock and obtains a response from the holder of the oplock, the first client device 130.

At a step 532, the file server 110 breaks the oplock by sending an "oplock-break" message 140 to the CIFS first client device 130.

When the second client device 130 is a CIFS client device 130, this is already expected. When the second client device 130 is an NFS client device 130, the file server 110 delays its response to the NFS (or NLM) protocol request message 140 until the CIFS first client device 130 responds to the "oplock-break" message 140.

At a step 533, the CIFS first client device 130 receives the "oplock-break" message 140, and can respond to the message 140 in one of two ways:

- The CIFS first client device 130 can close the file 113 (thus removing the file lock associated with the file-open); or

- The CIFS first client device 130 can flush all outstanding CIFS write and byte-range lock requests for the file 113 that are being cached locally at the client device 130 (that is, it can forward the results of those file system operations to the file server 110), and discard any read-ahead data it has obtained for the file 113. Read-ahead data should be discarded because the second client device 130 might subsequently write new data to the file, invalidating the read-ahead data.

At a step 534, the file server 110 receives the response from the CIFS first client device 130.

At a step 535, the file server 110 determines if the CIFS first client device 130 has maintained the file 113 open, and if so, compares the lock mode implied by the request by the second client device 130 against the new file-locking status of the file 113. If the file server 110 determines that the request by the second client device 130 is allowed to proceed, it continues with the flow point 540. If the file server 110 determines that the request by the second client device 130 is not allowed to proceed, it denies the request.

At a flow point 540, the file server 110 is ready to proceed to allow the request from the second client device 130 noted in the step 531.

Method of Operation (Change-Notify Manager)

Figure 6 shows a process flow diagram of a method of operating a change-notify manager in a multi-protocol file server.

A method 600 of operating a change-notify manager in a multi-protocol file server includes a set of process steps and flow points as described herein, to be performed by the file server 110 in cooperation with at least one client device 130.

At a flow point 610, the file server 110 is ready to receive the file server request message 140.

At a step 611, the file server 110 receives a file-open request message 140 from a first CIFS client device 130, designating a directory on the file server 110. The file server 110 determines that it should allow the file-open request and grants a CIFS file lock on the directory to the first CIFS client device 130.

At a step 612, the file server 110 receives a change-notify request message from the first CIFS client device 130, referencing the open directory, to convert the file lock on the open directory to a change-monitoring lock.

At a step 613, the file server 110 converts the file lock on the open directory to a change-monitoring lock on the designated directory.

At a flow point 620, the "change-monitoring" lock has been associated with the designated directory, and the first CIFS client device 130 is ready to be notified of changes to that directory.

At a step 621, the file server 110 receives a file server request message 140 from a second client device 130, requesting a change to the designated directory, and thus triggering a change notification to the first client device 130. (Types of change include file creation, file deletion, file rename, file move between directories, file attribute change, and file modification time change.) The file server request message 140 from the second client device 130 can be either CIFS or NFS. The second client device 130 can be any one of a Unix NFS client device 201, a PC NFS client device 202, or a CIFS Windows client device 203.

At a step 622, the file server 110 notifies the first client device 130, which holds the "change-monitoring" lock, of the changes noted in the step 621, containing possibly multiple entries, each of which specifies both the name of the changed file 113 or subdirectory within the monitored directory and the type of change. If there is more than one such first client device 130, the file server 110 notifies all of them.

Change-notification is known in the art of file-locking in Windows NT operating system environments. It is further described in documentation available for the "Windows NT 4.0" operating system, available from Microsoft Corporation of Redmond, Washington, including for example the CIFS IETF specification, available via the FTP protocol at host ftp.microsoft.com, directory /developr/drg/CIFS, files cifs6.doc or cifs6.txt, hereby incorporated by reference as if fully set forth herein.

At a flow point 630, the file server 110 has notified the first CIFS client device 130 of changes to the designated directory, and is ready for a next message 140.

Alternative Embodiments

Although preferred embodiments are disclosed herein, many variations are possible which remain within the concept, scope, and spirit of the invention, and these variations would become clear to those skilled in the art after perusal of this application.

Technical Appendix

Other and further information about the invention is included in a technical appendix enclosed with this application. This technical appendix includes 30 pages (including drawings) and is hereby incorporated by reference as if fully set forth herein.

Claims

1. A method of operating a file server, said method including steps for enforcing a uniform file-locking semantics among a set of client devices using a plurality of diverse file server or file locking protocols.

2. A method as in claim 1, wherein said uniform file-locking semantics includes opportunistic locks capable of

being requested by a first client device using a first protocol; and

breaking of said opportunistic locks being triggered by a second client device using a second protocol different from said first protocol.

3. A method as in claim 2, wherein said first protocol includes CIFS.

4. A method as in claim 2, wherein said second protocol includes NFS or NLM.

5. A method as in claim 1, wherein said uniform file-locking semantics includes steps for

granting an opportunistic lock on a selected file to a first said client device in response to a first message using a first said protocol; and

breaking said opportunistic lock in response to a second message using a second said protocol.

6. A method as in claim 5, wherein said steps for breaking include steps for

sending an oplock-break message to said first client device in response to said second message;

delaying execution of a file system request indicated by said second message;

receiving a response to said oplock-break message from said first client device; and

processing and responding to said second message after said step of receiving.

7. A method as in claim 1, wherein said uniform file-locking semantics includes a change-monitoring lock type capable of

being requested by a first client device using a first protocol; and a change notification being triggered by a second client device using a second protocol different from said first protocol.

8. A method as in claim 7. wherein said first protocol includes CIFS.

9. A method as in claim 7. wherein said second protocol includes NFS.

10. A method as in claim 1, wherein said uniform file-locking semantics includes steps for

granting a change-monitoring lock on a selected directory to a first said client device in response to a first message using a first said protocol; and

sending a change-notify message to said first client device in response to a second message regarding said selected directory using a second said protocol.

11. A method as in claim 1. wherein said steps for enforcing include steps for

recognizing a plurality of diverse protocols;

providing a uniform file-locking semantics in response to messages using at least one of said protocols; and

enforcing said uniform file-locking semantics for all said client devices.

12. A method as in claim 11, wherein said uniform file-locking semantics includes steps for

granting an opportunistic lock to a first said client device in response to a first message using a first said protocol; and

breaking said opportunistic lock in response to a second message using a second said protocol.

13. A method as in claim 12, wherein said steps for breaking include steps for

sending an oplock-break message to said first client device in response to said second message;

delaying execution of a file system request indicated by said second message;

receiving a response to said oplock-break message from said first client device; and

processing and responding to said second message after said step of receiving.

14. A method as in claim 11, wherein said steps for enforcing said uniform file-locking semantics include steps for

granting a change-monitoring lock in response to a first message from a first client device using a first said protocol; and

sending a change-notify message to said first client device in response to a second message using a second said protocol.

15. A method as in claim 11, wherein said steps for enforcing said uniform file-locking semantics include steps for

recognizing a selected message that attempts to violate said uniform file-locking semantics; and

responding to said selected message with an error response suited to a protocol associated with said selected message.

16. A method as in claim 11, wherein said steps for enforcing said uniform file-locking semantics include steps for

recognizing a selected message for obtaining a byte-range lock on a file in a selected said protocol, said byte-range lock having a lock type; and

testing whether obtaining said byte-range lock would conflict with existing locks created by messages using the same or other protocols.

17. A method as in claim 11, wherein said steps for enforcing said uniform file-locking semantics include steps for

recognizing a selected message for opening a file in a selected said protocol, said selected message including a requested access-mode; and

testing whether opening said file using said requested access-mode would conflict with existing locks created by messages using the same or other protocols.

18. A method as in claim 17,

wherein said selected message includes a requested deny-mode; and

including steps for testing whether opening said file using said requested deny-mode would conflict with existing locks created by messages using the same or other protocols.

19. A method as in claim 11, wherein said steps for enforcing said uniform file-locking semantics include steps for

recognizing a selected message for reading from or writing to a file in a selected said protocol; and

testing whether reading from or writing to would conflict with existing locks created by messages using the same or other protocols.

20. A method as in claim 1. wherein said steps for enforcing include steps for

receiving a first message using a first protocol, said first message being operative to lock at least a portion of a selected file;

receiving a second message using a second protocol, said second message being operative to request access to said portion;

comparing said access requested by said second message with said lock, and denying said access if prohibited by said lock.

21. A method as in claim 20, wherein said first protocol includes CIFS.

22. A method as in claim 20, wherein said first protocol or said second protocol includes NLM.

23. A method as in claim 20, wherein said second protocol includes NFS.

24. A method as in claim 20, wherein

said steps for receiving said second message include steps for recognizing said second message as being for obtaining a byte-range lock on a file using said second protocol, said byte-range lock having a lock type; and

said steps for comparing include steps for testing whether obtaining said byte-range lock having said lock type would conflict with existing locks created by messages using the same or other protocols.

25. A method as in claim 24, wherein said steps for testing are responsive to a protocol used for said second message.

26. A method as in claim 24, wherein said steps for testing operate at file-open time for a first said protocol and at an access time for a second said protocol.

27. A method as in claim 24, wherein said steps for testing operate at file-open time for a first said protocol and at a lock-request time for a second said protocol.

28. A method as in claim 20, wherein

said steps for receiving said second message include steps for recognizing said second message for opening a file using said second protocol, said second message including a requested access-mode; and

said steps for comparing include steps for testing whether accessing said file using said requested access-mode would conflict with existing locks created by messages using the same or other protocols.

29. A method as in claim 20, wherein

said steps for receiving said second message include steps for recognizing said second message for reading from or writing to a file using said second protocol; and

said steps for comparing include steps for testing whether accessing said file as attempted by said second message would conflict with existing locks created by messages using the same or other protocols.

30. A method as in claim 20, wherein

said steps for receiving said first message include steps for granting an opportunistic lock in response to said first message; and

said steps for comparing include steps for breaking said opportunistic lock in response to said second message.

31. A method as in claim 30, wherein said steps for breaking include steps for

sending an oplock-break message to said first client device in response to said second message;

delaying execution of a file system request indicated by said second message;

receiving a response to said oplock-break message from said first client device; and

processing and responding to said second message after said step of receiving.

32. A method as in claim 31, wherein said response to said oplock-break message includes an oplock-break acknowledgement message or a file close message.

33. A method as in claim 1, wherein said file-locking semantics includes a lock mode determined in response to an access-mode and a deny-mode requested by a first client device using a first protocol.

34. A method as in claim 1. wherein said file-locking semantics includes

a first lock mode determined in response to an access-mode and a deny-mode requested by a first client device using a first protocol; and

a second lock mode determined in response to a message from a second client device using a second protocol different from said first protocol;

wherein said file server is responsive to comparison of said first lock mode with said second lock mode.

35. A method as in claim 34, wherein said comparison includes a lock compatibility matrix.

36. A method as in claim 34, wherein said comparison includes a lock conversion matrix.

37. A method as in claim 34, wherein said second lock mode is responsive to a request for a byte-range lock.

38. A method as in claim 34, wherein said second lock mode is responsive to a request for a NLM file lock.

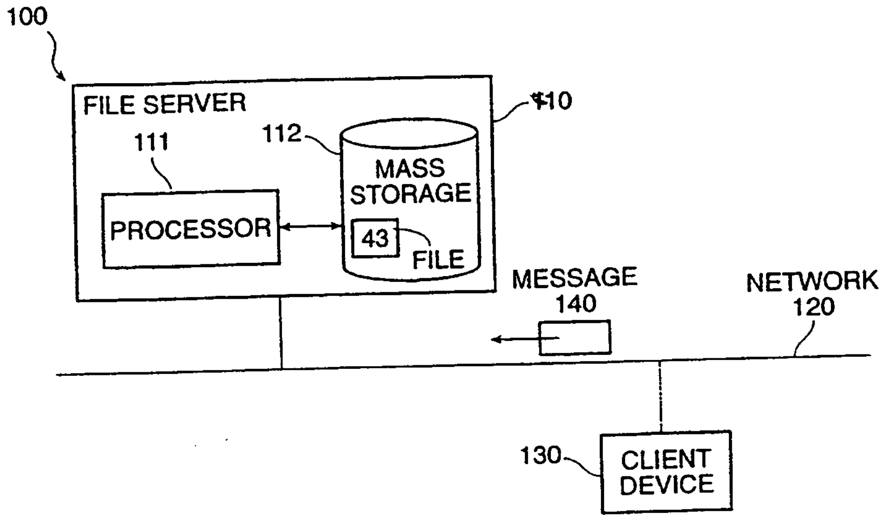
100
FILE SERVER
110
111
112
MASS STORAGE
PROCESSOR
43
FILE
MESSAGE 140
NETWORK 120
130
CLIENT DEVICE

FIG. 1

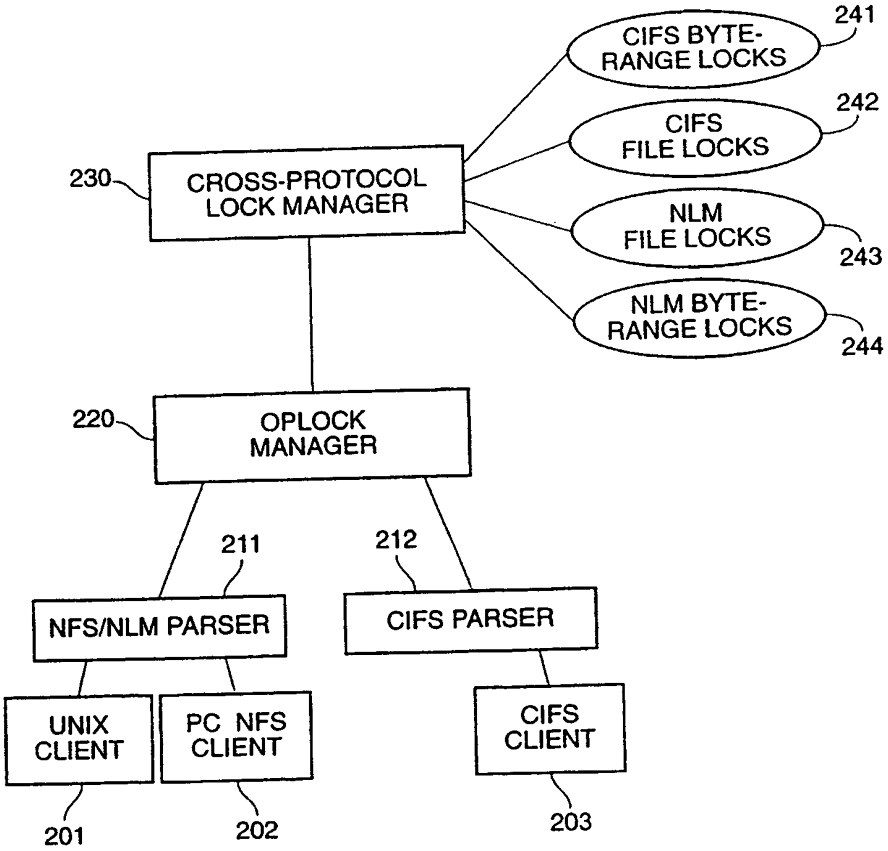
241
CIFS BYTE-RANGE LOCKS
242
CIFS FILE LOCKS
230
CROSS-PROTOCOL LOCK MANAGER
NLM FILE LOCKS
243
NLM BYTE-RANGE LOCKS
244
220
OPLOCK MANAGER
211
212
NFS/NLM PARSER
CIFS PARSER
UNIX CLIENT
PC NFS CLIENT
CIFS CLIENT
201
202
203

FIG. 2

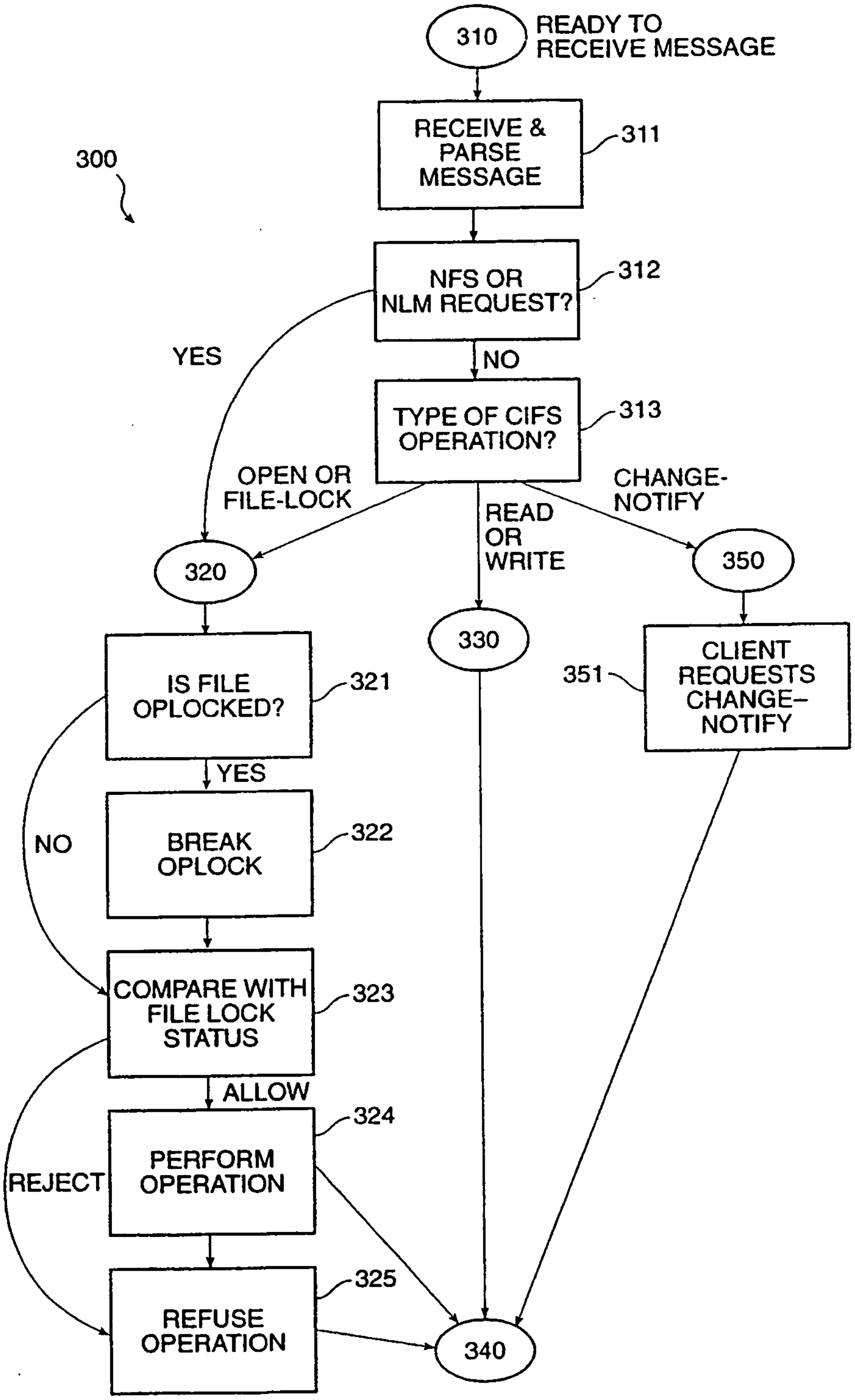
310
READY TO RECEIVE MESSAGE
RECEIVE & PARSE MESSAGE
311
300
NFS OR NLM REQUEST?
312
YES
NO
TYPE OF CIFS OPERATION?
313
OPEN OR FILE-LOCK
READ OR WRITE
CHANGE-NOTIFY
320
330
350
IS FILE OPLOCKED?
321
351
CLIENT REQUESTS CHANGE–NOTIFY
YES
NO
BREAK OPLOCK
322
COMPARE WITH FILE LOCK STATUS
323
ALLOW
324
REJECT
PERFORM OPERATION
325
REFUSE OPERATION
340

FIG. 3

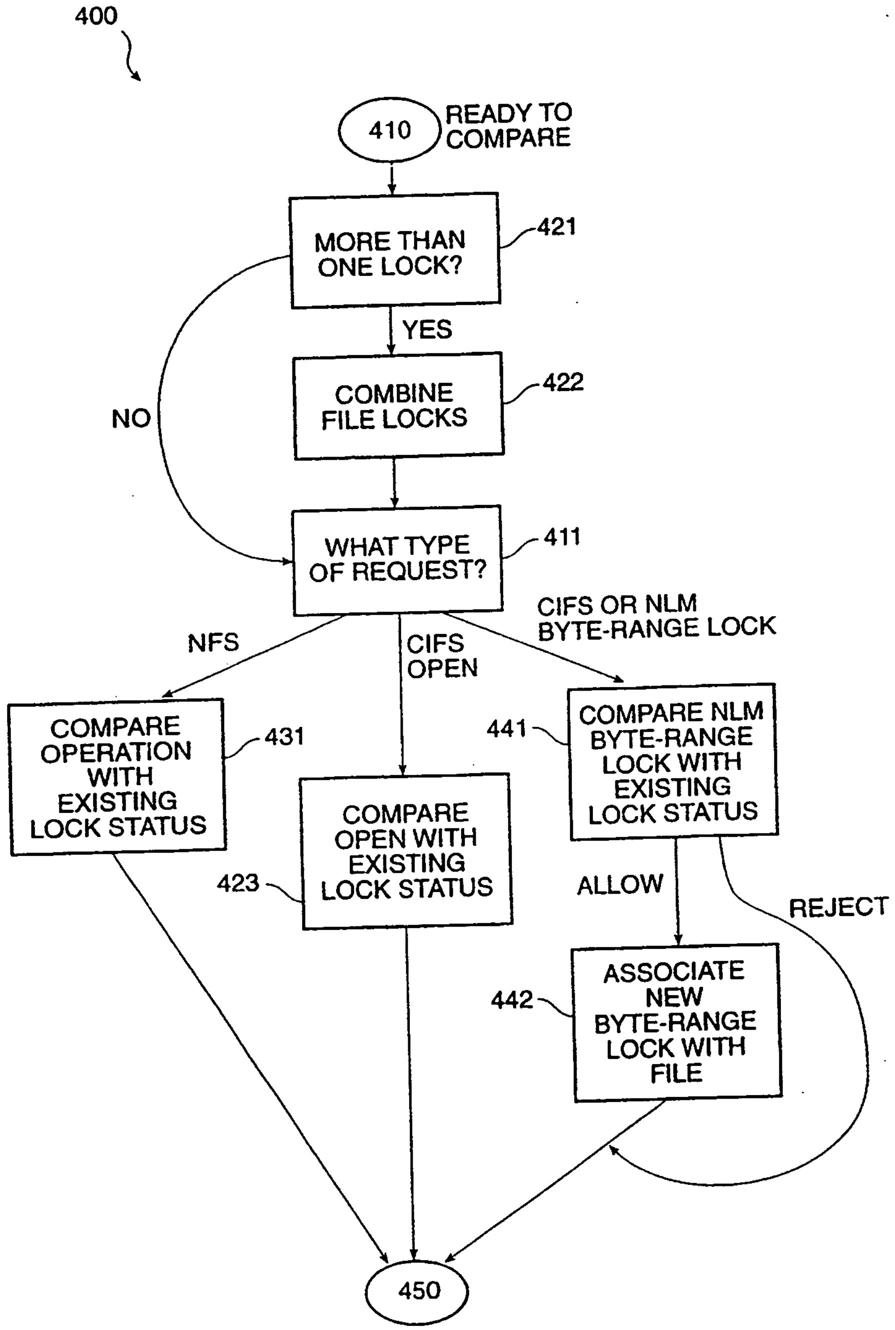
400
410
READY TO COMPARE
MORE THAN ONE LOCK?
421
YES
NO
COMBINE FILE LOCKS
422
WHAT TYPE OF REQUEST?
411
NFS
CIFS OPEN
CIFS OR NLM BYTE-RANGE LOCK
COMPARE OPERATION WITH EXISTING LOCK STATUS
431
COMPARE OPEN WITH EXISTING LOCK STATUS
423
441
COMPARE NLM BYTE-RANGE LOCK WITH EXISTING LOCK STATUS
ALLOW
REJECT
442
ASSOCIATE NEW BYTE-RANGE LOCK WITH FILE
450

FIG. 4

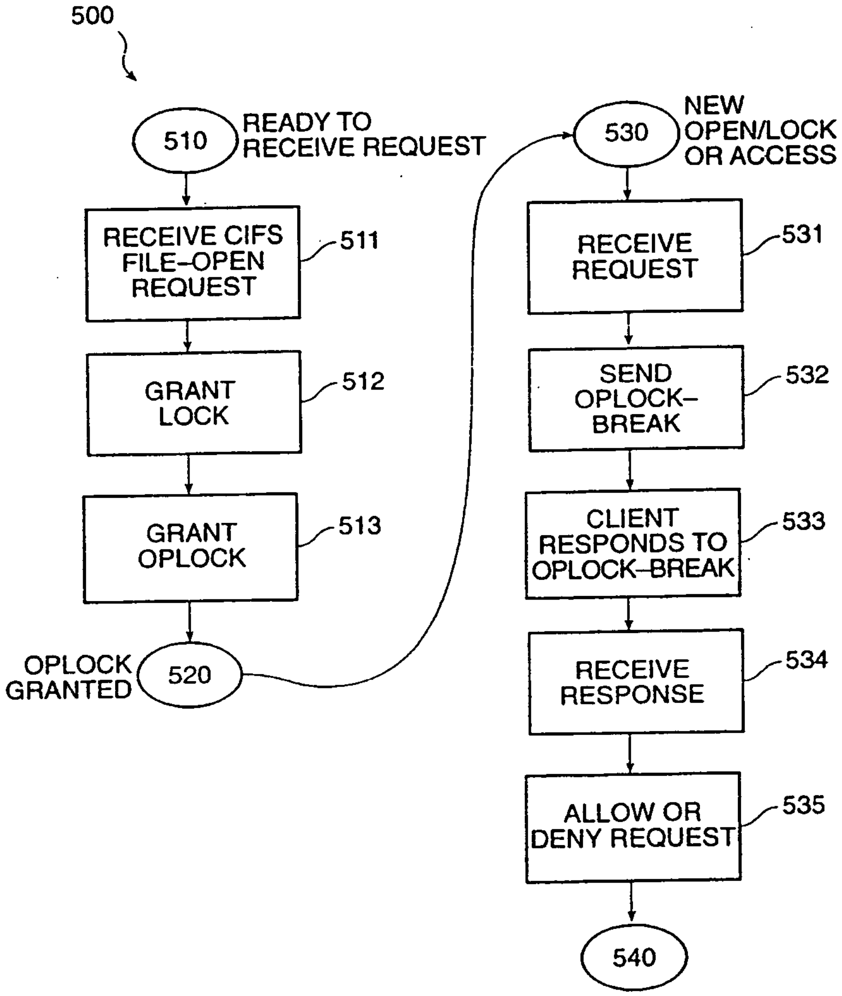
500
510
READY TO RECEIVE REQUEST
RECEIVE CIFS FILE-OPEN REQUEST
511
GRANT LOCK
512
GRANT OPLOCK
513
OPLOCK GRANTED
520
530
NEW OPEN/LOCK OR ACCESS
RECEIVE REQUEST
531
SEND OPLOCK-BREAK
532
CLIENT RESPONDS TO OPLOCK-BREAK
533
RECEIVE RESPONSE
534
ALLOW OR DENY REQUEST
535
540

FIG. 5

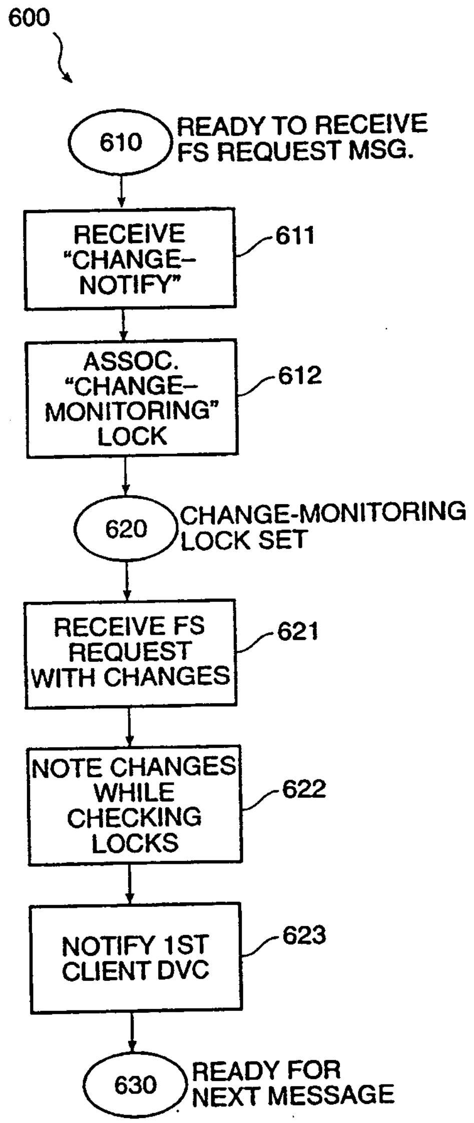
600
610
READY TO RECEIVE FS REQUEST MSG.
RECEIVE "CHANGE-NOTIFY"
611
ASSOC. "CHANGE-MONITORING" LOCK
612
620
CHANGE-MONITORING LOCK SET
RECEIVE FS REQUEST WITH CHANGES
621
NOTE CHANGES WHILE CHECKING LOCKS
622
NOTIFY 1ST CLIENT DVC
623
630
READY FOR NEXT MESSAGE

FIG. 6

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/US 98/25388

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F17/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	TANNER J: "CIFS: COMMON INTERNET FILE SYSTEM" UNIX REVIEW, vol. 31, February 1997, pages 31/32, 34, 36-41, XP000783952 see the whole document ---	1-38
A	US 5 261 051 A (MASDEN KENNETH E ET AL) 9 November 1993 see column 4, line 33 - column 7, line 5 --- -/--	1,2,5,6

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search 22 March 1999	Date of mailing of the international search report 07/04/1999
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Fournier, C

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/US 98/25388

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
P,X	BORR A J: "SecureShare: safe UNIX/Windows file sharing through multiprotocol locking" PROCEEDINGS OF THE 2ND USENIX WINDOWS NT SYMPOSIUM, PROCEEDINGS OF 2ND USENIX WINDOWS NT SYMPOSIUM, SEATTLE, WA, USA, 3-5 AUG. 1998, pages 117-126, XP002097387 ISBN 1-880446-95-2, 1998, Berkeley, CA, USA, USENIX Assoc, USA see the whole document -----	1-38

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. nal Application No

PCT/US 98/25388

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5261051 A	09-11-1993	AT 171797 T	15-10-1998
		AU 638481 B	01-07-1993
		AU 6165490 A	03-04-1991
		CA 2041660 A,C	15-02-1991
		DE 69032685 D	05-11-1998
		DE 69032685 T	25-02-1999
		EP 0438571 A	31-07-1991
		JP 2725885 B	11-03-1998
		JP 4502678 T	14-05-1992
		KR 9602030 B	09-02-1996
		WO 9103026 A	07-03-1991

PATENT COOPERATION TREA'I Y

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: STEVEN A. SWERNOFSKY
SWERNOFSKY LAW GROUP
P.O. BOX 390013
MOUNTAIN VIEW, CA 94039-0013

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of Mailing (*day/month/year*) **16 DEC 1999**

REPLY DUE within TWO months
from the above date of mailing

Applicant's or agent's file reference
NET-023

International application No.	International filing date (*day/month/year*)	Priority date (*day/month/year*)
PCT/US98/25388	30 NOVEMBER 1998	05 DECEMBER 1997

International Patent Classification (IPC) or both national classification and IPC
IPC(6):G06F 15/16 and US Cl.: 709/200

Applicant
NETWORK APPLIANCE, INC.

1. This written opinion is the first (first, etc.) drawn by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

I ☒ Basis of the opinion

II □ Priority

III □ Non-establishment of opinion with regard to novelty, inventive step or industrial applicability

IV □ Lack of unity of invention

V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

VI ☒ Certain documents cited

VII □ Certain defects in the international application

VIII □ Certain observations on the international application

3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. ~~The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).~~

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 *bis*.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 05 APRIL 2000.

Name and mailing address of the IPEA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer
FO Eugenia Logan
FRANK J. ASTA

Telephone No. (703) 305-3817

PATENT COOPERATION TREA1 Y

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: STEVEN A. SWERNOFSKY
SWERNOFSKY LAW GROUP
P.O. BOX 390013
MOUNTAIN VIEW, CA 94039-0013

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of Mailing *(day/month/year)*	16 DEC 1999	
REPLY DUE	within TWO months from the above date of mailing	
Applicant's or agent's file reference NET-023		
International application No. PCT/US98/25388	International filing date *(day/month/yea,* 30 NOVEMBER 1998	Priority date *(day/month/year)* 05 DECEMBER 1997
International Patent Classification (IPC) or both national classification and IPC IPC(6):G06F 15/16 and US Cl.: 709/200		
Applicant NETWORK APPLIANCE, INC.		

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2. This opinion contains indications relating to the following items:

I ☒ Basis of the opinion

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III □ Non-establishment of opinion with regard to novelty, inventive step or industrial applicability

IV □ Lack of unity of invention

V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

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4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 05 APRIL 2000.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer FRANK J. ASTA Telephone No. (703) 305-3817

WRITTEN OPINION

International application No.

PCT/US98/25388

I. Basis of the opinion

1. This opinion has been drawn on the basis of *(Substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".)*:

☒ the international application as originally filed.

☒ the description, pages 1-21, as originally filed.
pages NONE, filed with the demand.
pages NONE, filed with the letter of ______.

☒ the claims, Nos. 1-38, as originally filed.
Nos. NONE, as amended under Article 19.
Nos. NONE, filed with the demand.
Nos. NONE, filed with the letter of ______.

☒ the drawings, sheets/~~fig~~ 1-5, as originally filed.
sheets/~~fig~~ NONE, filed with the demand.
sheets/~~fig~~ NONE, filed with the letter of ______.

2. The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

3. □ This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:

NONE

WRITTEN OPINION

International application No.
PCT/US98/25388

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	NONE	YES
	Claims	1-38	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-38	NO
Industrial Applicability (IA)	Claims	1-38	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

Claim 1 lack novelty under PCT Article 33(2) as being anticipated by Blount et al. (Blount), (U.S. Patent No. 5,222,217).

Regarding claim 1, Blount discloses *a method of oprating a file server, said method including steps for enforcing file-locking semantics among a set of client devices using a plurality of diverse file server or file locking protocol* [Col. 6, lines 46-67, Col. 10, lines 21-55].

Claims 2-38 lacks an inventive step under PCT Article 33(3) as being obvious over Blount in view of Masden et al.(Masden), (US Patent No. 5,261,051).

Regarding claims 2,5, 7, 12, 13, 15-20 and 24-38, Blount discloses the invention substantially as claimed. Blount discloses breaking said opportunistic lock in response to a second message using a second said protocol [Blount, Col. 13, lines 57-65]. However, Blount does not explicitly disclose an opportunistic lock capable of being requested by a first client device using a first protocol and breaking of siad opportunistic locks being triggered by a second client device using a second protocol from said first protocol.

In the same field of endeavor, Masden discloses in an analogous art a method and means for improving the performance of distributed computer system. Masden discloses *an opportunistic lock capable of being requested by a first client device using a first protocol and breaking of siad opportunistic locks being triggered by a second client device using a second protocol from said first protocol* [Masden, Fig. 6 and 7, Col. 4, lines 33-58 and Col. 7, line 5] *and steps for comparing include steps for breaking said opportunistic lock in response to said message* [Col. 9, lines 50-65] and receiving a response to said op-lock break message to said first client device in response to said second message [Col. 9, lines 58-65].

Regarding claims 3, 4, 8, 9, 21, 22, and 23, Blount-Masden discloses the invention substantially as claimed. Henson disclosess protocol includes CIFS and a second protocol includes NFS or NLM [Henson, Col. 5, lines 35-61].

Claims 10 and 14 lacks an inventive step under PCT Article 33(3) as being obvious over Blount-Masden and further in view of (Continued on Supplemental Sheet.)